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# Spacecraft charging and its influence on low-energy ion measurements made by Rosetta-ICA

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## Abstract

Spacecraft charging causes inevitable issues when doing low-energy ion measurements in space. For the ion spectrometer ICA on board the Rosetta spacecraft, the charging of the spacecraft causes severe distortions of the low-energy part of the data. The positive ions are attracted to the negatively charged spacecraft, resulting both in a shift of the energy spectrum and a distortion of the field of view (FOV) of the instrument. Due to these distortions, the low-energy part of the data remains unexploited. The aim of this study is to determine the influence of the spacecraft potential on the low-energy ion measurements made by ICA. To achieve this, we perform simulations with the SPIS software. The results show that the travel direction of the ions can be trusted when their energy is at least twice the spacecraft potential. The FOV distortion differs between different pixels of the instrument, and the severity of the distortion is dependent on both the energy of the ions and where they are entering the instrument.

## 1. Introduction

Rosetta is a unique space mission. It is the first spacecraft to ever orbit a comet nucleus, and the first spacecraft to follow a comet for an extended amount of time as it approaches the Sun. Rosetta hence provides important new insights into the nature of comets. To fully exploit the data obtained by Rosetta, however, we have to deal with one unavoidable issue: the charging of the spacecraft surface. Interactions between the spacecraft and the surrounding plasma cause currents to, and from, the surface, charging it to a negative potential. This, in turn, causes interferences with the instruments on board.

One instrument on board Rosetta, suffering from this interference, is the Ion Composition Analyzer (ICA) [2]. ICA is a mass resolving ion spectrometer measuring positive ions, with the purpose of studying how the cometary particles interact with the solar wind. The instrument covers an energy range of a few eV to 40 keV, but the low-energy part of the observed ion distribution is heavily distorted by the spacecraft potential. The positively charged ions are attracted to the negatively charged spacecraft, causing a change in both energy and travel direction of the ions, which in turn distorts the FOV of the instrument.

The distorted low-energy part of the data is important in order for us to fully understand the environment around the comet, since the newly born ions are believed to be initially cold [1].

The purpose of this study is to, through simulations with the SPIS software, determine the influence of the spacecraft potential on the low-energy ion measurements made by ICA.

## 2. Method

The Spacecraft Plasma Interaction Software (SPIS) [3] is a simulation tool developed to study the interactions between a spacecraft and the surrounding plasma. It uses a Particle-In-Cell (PIC) approach to model these interactions, and the possibility exists to also add scientific instruments to the simulation which can be used for e.g. particle tracing. By tracing particles backwards from an instrument model representing ICA, we study the FOV distortion of the instrument for different ion energies. One example of particle tracing results from one sector (nominal FOV of 22.5° x 90°) of the instrument is shown in Figure 1, for both a high energy (more than twice the spacecraft potential) and a low energy (a few eV) of the ions. The FOV is heavily distorted for the low energies.

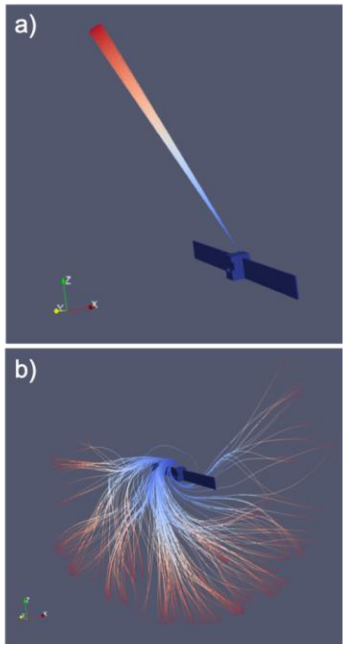


Figure 1: Particle tracing results for a) a high energy (more than twice the spacecraft potential) and b) a low energy (a few eV) of the ions.

## 3. Results and conclusions

Figure 2 shows how the FOV distortion changes as the ion energy decreases. The simulations are made for one sector (same as in Figure 1) of the instrument. Each panel shows the FOV of the instrument, with azimuthal angle on the x-axis and elevation angle on the y-axis. The dashed square represents the nominal FOV of the sector, while the color scale shows the normalized flux of particles at the external boundary actually reaching the sector. Three energy levels are presented. The highest one corresponds to approximately twice the spacecraft potential (-21 V for this simulation). The travel direction of the ions at infinity more or less coincide with the FOV of the instrument for this energy, but when the ion energy is lower the distortion gets more severe.

In this presentation, simulation results for different sectors and smaller pixels of the instrument will be presented and compared. It then becomes apparent that the location of the pixel with respect to the spacecraft body determines the severity of the FOV distortion. Furthermore, first results from a sensitivity analysis looking at the sensitivity of the simulation results to changes in e.g. the plasma environment will be presented.

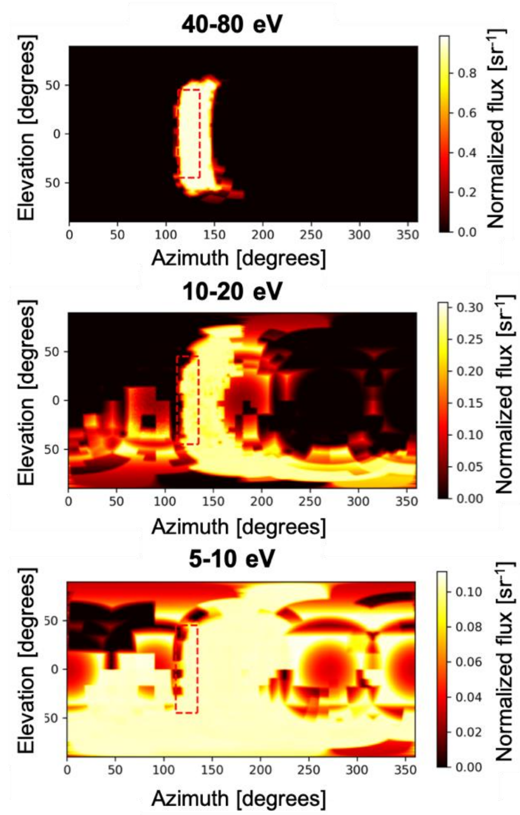


Figure 2: Results showing the FOV distortion for different energies for one sector of the instrument. The dashed square represents the nominal FOV of the sector while the color scale shows the flux of particles at the external boundary actually reaching the sector.

## Acknowledgements

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